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ABSTRACT

A research project investigated the process of reading comprehension through which the reader generates a semantic representation of the message conveyed by a text. The first focus of the project was an examination of the functioning of abstract knowledge in text comprehension. Studies were conducted to explore the activation of proposition schemata and the use of such schemata in constraint checking and encoding implicit propositional arguments. Other studies provided evidence that episode schemata remain activated in memory as episodes are encoded. Additional studies examined the consequences of a mismatch between input and activated schemata, investigated the retrieval of abstract semantic knowledge, reviewed retrieval of abstract world knowledge and prior information in a text in coherent anaphoric references, and explored the use of stored orthographic knowledge, phonetic knowledge, and semantic knowledge in word recognition. The second focus of the project concerned the nature of text representation and the retrieval of prior information in a text. Two studies looked at the role of clause structure in integrating new information and in retrieving information from memory. Additional studies examined a process theory of pronoun disambiguation and employed reading time in processing anaphoric reference to examine frequency and importance as factors in retrieving prior text information. Theories were developed concerning the representation of context in text structure and chunking and consolidation in memory. (Author/RL)

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FINAL REPORT

Title of Project: Reading Comprehension and Semantic Memory.

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Name of Institution: University of Oregon

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This research project investigates the process of reading comprehension through which the reader generates a semantic representation of the message conveyed by a text. Comprehension may be described as an active process because the semantic structure that is developed does not consist entirely of imformation explicitly referenced in the text. Instead, comprehension requires that the reader draw inferences as new propositions are integrated into the text structure. These inferences are drawn on basis of abstract knowledge of the world in conjunction with prior information already encoded in the text structure. Consider the sentence As the woman opened her door she was startled by the burst of noise. Two explicit propositions are encoded the woman opened the door and the woman was startled by the burst of noise, connected by a conjunctive relation. In integrating these sentences the reader must recognize that she in the second proposition refers to the woman in the first proposition. In addition, the reader would need to retrieve prior information in the text, e.g., the woman's friends decided to give her a surprise party for her birthday. This prior knowledge along with abstract knowledge of surprise parties (i.e., an episode schema) allow the reader to identify the burst of noise (people yelling "surprise") and understand its relation to the woman opening her door. This project has two major thrusts. One concerns the retrieval and functioning of abstract world knowledge. The second concerns the nature of text representation and the retrieval of prior information in a text.

The first focus of project examines the functioning of abstract knowledge in text comprehension. When abstract knowledge of objects, relations and events is activated in memory, that knowledge provides a contextual framework for the interpretation of words in the text. Studies were conducted that examine the activation of proposition schemata, and the use of such schemata in constraint checking and encoding (inferring) implicit propositional arguments. Other studies provide evidence that episode schemata (general knowledge of episodes, e.g., going to the beach) remain activated in memory as episodes are encoded and examine the consequences of a mismatch between input and activated schemata (constraint violations). Further studies examined the retrieval of abstract semantic knowledge (category membership relations) and examined retrieval of abstract world knowledge and prior information in a text in disambiguating anaphoric references. Finally, a series of studies examined the use of stored orthographic knowledge, phonetic knowledge and semantic knowledge(noun-verb class) in word recognition.

Information is input serially in reading. As new propositions are integrated into a text structure it is necessary to retrieve prior information already encoded in that text structure. The second major thrust of the project examines text structure, the retrieval of information from text structures and integration of new propositions into the structures. Two studies examine the role of clause structure in integrating new information and in retrieving information from memory. A context-sensitive theory of syntax representation has been developed and a study of memory for syntactic information (subject-object relations) was conducted. An additional set of studies examined a process theory of pronoun disambiguation. An additional set of studies employed reading time in processing anaphoric reference to examine frequency and importance as factors in retrieving prior information in a text. Finally, theories were developed concerning the representation of context in text structure and concerning chunking and consolidation in memory.

Proposition Schemata-Argument Activation and Inferences

Instrument Inferences A series of studies has investigated the encoding of implicit propositional arguments, specifically instruments. Instruments are tools employed to accomplish some activity, but may remain implicit in a description of the activity, e.g., The lawyer swept the floor. The "swept" sehema contains information about constraints on the instrument, but also contains knowledge of typical or probably instruments (i.e., broom). A series of studies supported by this project (Corbett & Dosher, 1978) examines whether readers infer implicit instruments during reading. That is, in reading The salesman pounded the nail, does the reader encode an instance of the concept hammer as part of the proposition in the semantic representation of the text. The actions employed in this study each accept a highly likely instrument. Therefore, a more general question under investigation is: does the reader routinely draw (encode) highly probable inferences when those inferences are relatively unnecessary for comprehension (e.g., it is not necessary to know whether the sailor used a spoon in processing the sailor stirred his coffee.

Other researchers have concluded that such instrument inferences are, in fact, encoded routinely in reading, at least by adults. Paris and Lindauer, (1976) for example, presented subjects with a list of sentences describing actions which have highly plausible instruments. In some sentences the instrument was explicit (The lawyer cooked dinner on a stove) and in some remained implicit (The lawyer cooked dinner). Paris and Lindauer found in a subsequent cued recall task that with fifth graders (although not with younger children) implicit and explicit instruments were equally effective recall cues. Based on Tulving's encoding specificity theory (Tulving and Watkins, 1975) Paris and Lindauer argued that implicit instruments must be encoded when the sentences were read.

To examine this conclusion a series of studies was conducted. First, a set of instrument completion norms was collected (Corbett & Dosher, 1977). One hundred subjects were presented with 67 sentences which require instruments, e.g., The man stirred his coffee with (a) _____. Subjects were asked to write down two objects that could be employed to perform the activity. These norms provide previously unavailable objective measures of instrument plausibility.

These instruments norms were employed in designing three cued recall studies to examine the encoding of implicit instruments (Corbett & Dosher, 1978). The first study was similar to Paris and Lindauer (1976), but a third learning condition was included. In the list presented to subjects, one-third of the sentences explicitly referenced high-probability inferences (The tailor cooked dinner on a stove)one third had no explicit instrument (The tailor cooked dinner) and one third referenced a low probability instrument (The tailor cooked dinner on a campfire). An immediate recall test revealed that high probability instruments were equally effective retrieval cues in all three learning conditions, including the last in which an alternative instrument was encoded in learning. Thus, retrieval cue effectiveness is not a valid indicator that implicit high probability instruments are being inferred (encoded) in learning. Instead, recall cue effectiveness may be mediated by abstract knowledge of action-instrument relations.

In addition, subjects were extremely accurate in recall at discriminating whether or not a high probability instrument had been presented in learning. This would not be expected if subjects were inferring and encoding high probability instruments in learning. Two additional studies with similar designs

demonstrated that even after a thirty minute retention interval, subjects are still extremely accurate at discriminating whether high probability instruments had been present in learning. Results concerning storage dynamics for surface structure (i.e., words) and semantic information (Begg & Wickelgren, 1974; Sachs, 1974) suggest that performance in these two studies are, in fact, based on semantic representations of the propositions in memory rather than information concerning specific words presented in learning. Again, this indicates that subjects are not routinely inferring and encoding high probability instruments in learning.

Instrument Priming. A series of studies has examined the priming of implicit instruments in reading (Dosher & Corbett, forthcoming). These studies employ a Stroop task to assess concept priming. In this paradigm, test words are presented in colored ink and the subject is required to name the ink color aloud. Response times are slowed if the test word refers to a recently primed concept (Conrad, 1974).

In the first study, subjects were presented sentences which accept a highly likely instrument, e.g., He cleaned the floor, for three seconds. Immediately following each sentence a Stroop word was presented. This word was either a highly-likely instrument (e.g., mop), a less-likely instrument (e.g., sponge) or an unrelated object (e.g., hammer). The stimuli were selected from Corbett & Dosher (1977). The study failed to reveal any evidence of priming of the highly-related instruments. This result, suggesting that abstract knowledge of highly-likely instruments is not primed in reading, is perhaps surprising, but, if replicated, strengthens the conclusions of Corbett and Dosher (1978) that instruments are not routinely inferred and encoded in sentence processing.

Two other studies investigated activation of a different class of instruments, body part instruments (e.g., wing in The duck flew over the lake). These instruments represent a different class of instruments, not only because they are body parts, but also because (1) they are implied by the verb alone rather than by verb-object phrases (i.e., wash the floor suggests mop, while wash alone need not), and (2) these body-parts represent constraints on the agent of the proposition. That is, the agent must possess the body part for the sentence to make sense (e.g., The dog flew over the lake is nonsensical). Thus, it may be that body part instruments are primed in sentence comprehension as part of the constraint checking process. In one of the two studies, the priming stimuli were sentences requiring a body part instrument (e.g., The goat kicked the fence), and in the other study the priming stimuli were the corresponding verbs alone (e.g., kicked). There were two types of Stroop words (1) The body part instrument - leg and (2) a high associate of the verb, e.g., ball. These Stroop words were presented either in context-following the related sentence or verb-or out of context-following an unrelated sentence or verb. In addition, practice effects were examined, i.e., performance was analyzed separately for the first-half trials and second-half trials in each task.

The results for the first half of each task were quite similar. Evidence was obtained of body part instrument priming following both the related verbs and sentences. Interestingly, high associates showed a reverse Stroop effect suggesting that the high assiciates are being suppressed. This suppression effect was eliminated with practice and in the second half trials evidence of high-associate priming was obtained. The practice effects on instruments were more complex. With the sentence primes, an instrument priming effect was still obtained in the second half. With verb primes, however,

no evidence was obtained in the second half of instrument priming (or suppression).

The difference then between verb processing and sentence comprehension appears to be that, with isolated verb primes the subjects can come to ignore instrument information with practice (thus, the absence of a priming effect in the second half of the verb-primg study), but cannot come to ignore instruments during sentence comprehension. This result suggests that these body part instruments are primed as part of a constraint checking process in sentence comprehension.

Episode Schemata in Comprehension

Schema Activation. In comprehension the reader draws on abstract world knowledge and prior information in the text to encode inferences. One type of abstract knowledge employed in comprehension is an episode schema or script (Bower, Black & Turner, 1979; Graesser, Gordon & Sawyer, 1979; Schank & Abelson, 1977). An episode schema is the representation in memory of general knowledge concerning an episode (e.g., eating dinner in a restaurant). This information has been abstracted from past experience with the episodes and contains knowledge of necessary components (e.g., customers food), typical components (e.g., menus, waiters) and relations between the components (e.g., customers order food from the waiters after looking at the menu). In comprehension, high level episode schemata are activated and serve as an important basis for interpreting words in a text, processing reference and inferring relations. We reasoned that if these large scale schemata play an ongoing role in comprehension, they should remain in an activated state throughout the course of the episode. A probe recognition paradigm was employed to test this hypothesis.

On each trial of the present study, subjects read two sentences that, in effect, told a very short story. The first sentence described an episode and included an explicit, one-word label for the episode (e.g., picnic in The Andersons went out for a picnic and spread a blanket under a tree). The second sentence in each trial was drawn from one of three conditions. In the first condition, the episode was continued and explicitly referenced again (e.g., During the picnic the Andersons ate sandwiches and tossed around a football. In the second condition the episode was continued, but the episode label was not repeated (e.g., The Andersons ate sandwiches and potato chips and tossed around a football). In the third condition, a new episode was introduced (e.g., That night the Andersons gathered around the television and watched a movie). After the subject read the two sentences a probe word was presented and the subject decided as quickly as possible if the word appeared in either of the two sentences. In the trials of interest, the probe word was the episode label (picnic). Response time in this task is fastest when the concept referenced by the probe word has recently been activated or primed (Caplan, 1972; Ratcliff & McKoon, 1978; Chang, in press). Therefore, it was predicted that responses to the episode prove would be faster following sentences in the first two conditions in which the episode continues in the second sentence. In addition, probe responses were expected to be faster in the first condition (in which the actual label is repeated) than in the second condition, because of the name match in the first condition.

In fact, the predicted results were obtained. The overall difference between conditions was significant, and the paired comparisons were at least marginally significant. Thus, evidence has been obtained with short, two-sentence stories, of continuing activation of episode schemata when those schemata provide a context for encoding the input.

Constraint Violations. Two further studies examined the effects on reading time of constraint violations, that is, the effects of a mismatch between incoming information and the schemata that are activated and providing a context for encoding. A proposition or an episode schema contains information on necessary components and typical components; information on relations between the components and constraints on the components. Serious conflicts between the input and constraints indicate that an inappropriate schema has been activated and the reader must make adjustments. In the present study we examine the effects of constraint violations that may be resolved by activating an alternative, well-known schema.

The dependent measure in these studies was reading time. Subjects read a one-paragraph story at a self-paced rate. Four versions of the story, which described a bank robbery, were generated. In two of the four conditions a constraint violation was presented midway through the story (a man flies out of a window). In one of these conditions, subjects had also been given the title Superheroes before reading the story(the story was about comic book heroes.) Two control groups did not process a constraint violation at this point. One of these control groups was also given a title, Superhero, prior to reading the story. Later in the story, near the conclusion, the same violation was presented to all four groups (a woman flies onto the scene and lifts a car into the air).

The results of this study were essentially as anticipated, although the effects of the two violations were at least quantitatively different. The initial violation slowed reading time, relative to the two control groups, as the readers were forced to do some recoding (e.g., the man is a superhero). This effect was greater for the violation group that had not been presented a title. Presumably, this group was forced to perform more extensive recoding of the story schema (i.e., the story is a fantasy) which the title group had already accomplished. Similarly, the effects of the later violation were greater for the group that had not been given a title before reading.

The second violation had a large and prolonged effect on the two groups that had received no prior violation; the effects were much greater than the effects of the first violation on the other two groups. A second study was conducted that examined a possible explanation of this quantitative difference. The woman involved in the second violation had not previously been introduced, while the man in the first violation had been. It is possible that there is an interactive effect of encoding new concepts in conjunction with constraint violations. In this second study, all four versions of the story were modified so that the woman was referenced prior to the constraint violation. This second study confirmed the general conclusions of the first study. Constraint violations slowed reading time, but the presence of a relevant title or prior violations attenuated this effect. In addition, the effects of the late violation (for the groups receiving no prior violation) were smaller in comparison with effects of the earlier study. Thus, there is some evidence that introducing a new concept interacts with the constraint violations, increasing the difficulty of the required recoding.

Semantic Memory Retrieval

In a study partially supported by this grant, Corbett and Wickelgren investigated activation and retrieval of information in semantic memory. Retrieval of information from memory appears to activate or prime related

information in memory, making that primed information more readily accessible. We have previously considered the role of activation in constraint checking and inferencing. The present study examined activation in a categorization task in which subjects decide if a test instance is a member of a category, e.g., Is a tulip a flower? Previous studies have reported that repeating a category on successive trials speeds response time in this task, and argued that residual activation of a category from trial n-1 speeds retrieval on trial n. The present study investigated whether this activation is primarily a function of concept encoding (i.e., reading a category name, for instance animal) or a function of relation retrieval (i.e., retrieving a category membership relation, for instance, a dog is an animal). This was accomplished by presenting the target category name on each trial two seconds prior to presentation of the test instance. If activation results from category concept encoding that activation will be present during retrieval of the category-test instance relation, not only when a category is repeated, but also the first time it is presented. In this case, there should be no speeding of retrieval on successive trials with the same target category. There was, in fact, no effect of repeated category presentation in this experiment. This result supports the position that activation of category instances in a categorization task results from the encoding of the category name and not from the encoding and verifying of specific category-membership relations. This contrasts with the activation of body-part instruments in the earlier constraint checking experiment in which evidence was presented that body part activation stemmed from the encoding of a proposition and not from encoding individual words in a sentence.

This study also examined the retrieval of category-membership relations from semantic memory. Several previous experiments have demonstrated that some members of a category can be categorized faster than others (e.g., response time is faster for verifying that a robin is a bird than for verifying a pigeon is a bird). This effect may be referred to as dominance; high domanant category examples are categorized more quickly than low dominant examples. Dominance is highly correlated with total production frequency of examples in a task where subjects generate examples of categories, but it is also less highly correlated with semantic similarity ratings for category-example pairs.

Several models of memory retrieval have been proposed that account for this effect. Anderson and Bower (1973) and Rosch (1973) propose that category examples are retrieved through a serial self-terminating search of the category members stored in memory. The search order is fairly constant and high dominant examples are those that are encountered first on the list of category examples. Juola, Fischler, Wood and Atkinson (1973) propose a two stage model. The first stage consists of a direct-acess retrieval process which generates a "yes" response if the tested relation is very strong (e.g., animal-dog) and a "no" response if the relation is very weak (e.g., animal-chair). If the tested relation is of intermediate strength, a second stage is invoked, consisting of a serial search of the category examples stored in memory. Thus, high dominant relations are strong and are verified quickly in the first stage. Low dominance examples require the second stage for verification and therefore lead to slower response times. Rips, Shoben and Smith (1973) propose a two-stage feature comparison model of categorization. In the first stage all semantic features of the target category and test instance are compared. High feature overlap leads to a "yes" response and low feature overlap leads to a "no" response. With intermediate levels of overlap, a second stage is required in which features are compared more carefully, that is, with greater weighting assigned to more defining features.

In this model, high dominant examples (e.g., bird-robin) are very similar to the category concept and are accepted after the first stage of processing. Low dominant members (e.g., bird-penguin) are less similar to the category concept and require the second stage of processing for acceptance.

A fourth model, a simple parallel or direct access model proposes that dominance effects reflect differences in strength or degree of learning. This model predicts that if full retrieval functions are obtained (in which accuracy is measured as a function of processing in retrieval), there will be no differences in retrieval dynamics or retrieval speed across dominance levels. Instead, accuracy at the asymptote should be directly related to dominance level. All of the preceding models predict faster retrieval dynamics as well as higher asymptotic accuracy for high dominant examples.

The present study employed a categorization task with dominance (three levels) as an independent variable. Reed's (1973) interruption method was used to obtain 10-point retrieval functions (in which response accuracy is plotted as a function of elapsed processing time). Dominance level was directly correlated with asymptotic accuracy in the task and was unrelated to retrieval speed (the rate at which information is retrieved from memory). Thus, the results of the experiment are consistent with direct access or parallel retrieval of information from semantic memory and contradict the predictions of the serial search model and both two-stage retrieval models.

Anaphoric Reference: Abstract Knowledge and Prior Information. An additional series of studies employed reading time as a dependent measure to study anaphoric reference and integrate two major foci of this project: the retrieval of abstract world knowledge and the retrieval of prior information in a text (Corbett, forthcoming). These studies examined the use of generic and non-generic adjectives in disambiguating anaphoric reference. In these studies, subjects read brief stories, one word at a time, at a self-paced rate. An adjective-noun anaphoric reference (e.g., large jewel) appeared near the end of each story. The antecedent had been referenced earlier as an instance of the noun category (e.g., large emerald). In half the stories, the antecedent was the only category member mentioned earlier in the story. In the other stories a non-antecedent category member (e.g., small ruby) had also been mentioned earlier. When such a distractor was present, of course, the adjective in the anaphoric reference had to be employed to disambiguate the reference.

The first two studies revealed that, as expected, reading time for the adjective-noun anaphoric reference was greater when a non-antecedent distractor was present. Thus, while word-by-word reading time seems to be relatively insensitive to comprehension with single sentences (Aaronson & Scarborough, 1976; Chang, in press; Corbett & Chang, forthcoming) it seems to be an effective measure with multi-sentence story stimuli. In addition, the nature of the adjectives varied across the two stories. In the first story, non-generic adjectives were employed. That is, the adjectives did not describe an inherent property of the antecedent (i.e., emeralds are not inherently large gems). The earlier reference to the antecedent necessarily included the non-generic adjectives. In contrast, the anaphoric adjective in the second study was generic, that is, it did describe an inherent property of the antecedent (e.g., green gem in reference to an emerald). In this study, the prior reference to the antecedent did not include the generic adjective, but instead included the non-generic adjective from the first story. The assoc-

iative interference effect (effect of a distractor in the story) was two to three times larger in the first study employing non-generic adjectives than in the second study.

There are at least two explanations of the difference between generic and non-generic adjectives. In the second study employing generic adjectives, subjects need only retrieve abstract knowledge of gems to disambiguate the reference, since in fact, all emeralds are green. In the first study, with non-generic adjectives, subjects must retrieve the actual instances of the anaphoric concept in the text to disambiguate the reference, since the non-generic adjectives are predicated of the specific instances rather than the abstract concepts. It may be that the abstract information can be retrieved and processed more efficiently. An alternative explanation suggests that the generic adjectives are processed faster because they are more strongly associated with the antecedent. A third study was conducted to examine these theories.

The third study employed non-generic adjectives, but varied the strength of the adjective-antecedent relations. Again, each story contained an anaphoric adjective-category reference (e.g., rubber toy to an antecedent (e.g., rubber ball). In half the stories there was also a distractor non-antecedent (e.g., wooden block). Two adjectives were selected for each story on the basis of association norms. One was a high associate of the antecedent (e.g., rubber in rubber ball) and a low associate of the distractor (e.g., rubber block). The other adjective reversed this relationship (wooden ball, wooden block). Thus, four versions of each story were constructed. All contained the same antecedent (e.g., ball). In two of the four versions a distractor was present (e.g., block). Crossed with this, the adjective included in both the initial reference to the antecedent and in the anaphoric reference was either a high associate of the antecedent (e.g., rubber toy) or a low associate (e.g., wooden toy).

The results support the associative strength hypothesis. Reading times were significantly slower with low strength adjectives and were also slowed by the presence of a non-antecedent distractor. However, as a strength theory predicts, the presence of a distractor slowed reading time much less when the disambiguating adjective was a high associate of the antecedent.

Activation in Word Recognition

Semantic Expectations and Nonwords. The preceding studies emphasized the impact of semantic expectations - such as generation of expected instruments and episode schema constituents - on general comprehension performance. Semantic information may also impact on the recognition of individual lexical items: it is often claimed that expectations generated during reading make word recognition faster and easier. The common finding in lexical decision studies is that presentation of the single context word DOCTOR results in a faster identification of the word NURSE. (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt & Ruddy, 1975). This finding that single word contexts can speed word recognition may generalize to multi-word or sentence contexts.

The previous studies, like those of Meyer et.al.,have demonstrated a priming effect for word pairs like DOCTOR-NURSE. In these pairs, priming of the general medical concepts is confounded with the possible priming of the spelling and sound patterns of the specific lexical entry NURSE. In an

attempt to separate general conceptual priming from specific lexical priming we looked, instead, for an inhibitory effect of a prime. DOCTOR, on the classification of a close misspelling of a high associate NURSE: NIRSE or NVRSE, both of which are nonwords.

Some theories of word recognition (see Meyer et.al , 1971;1975) have suggested a two stage model in which letter strings are coded, either visually or phonetically,and then a search is made of lexical memory to determine whether that letter string is a word. Usually the claim is made that unpronounceable letter strings are falsified at a very early stage of processing. If unpronounceable strings, like NVRSE, are falsified prior to searching semantics or lexical memory, then semantic context should have no effect on perception of this item.

The first study employed a list of semantic associates (like NORTH-SOUTH or YOUNG-OLD) obtained from Becker and Killion(1977). Analysis of the list revealed that 97% of the words were single syllable. For each target word, a pronounceable misspelling and an unpronounceable misspelling were generated. There were six kinds of trials. Three trial types were in context: word-word (YOUNG-OLD); word-prounceable nonword (YOUNG-ALD); and word-unpronounceable nonword (YOUNG-CLD). The remaining three types were control trials consisting of randomly paired context and target stimuli.

The standard priming condition (YOUNG-OLD) resulted in a typical 37 msec savings in reaction time for the in-context condition relative to the out of context control. The usual finding that pronounceable nonwords (out of context) take longer to classify than unpronounceable nonwords was also obtained (880 msec and 821 msec respectively). The conditions of most interest involve the nonwords in context (nonwords that differ by a single letter from a word that is associated with the context item). Placing these nonwords in context resulted in a significant - 20 msec slowing in lexical decision time relative to their out of context controls. The slowing in decision time was larger for the pronounceable nonwords (-34msec) than for unpronounceable nonwords (-2msec). However, this was not due to an early stage rejection of the unpronounceable nonwords. Rather, these nonwords in context (YOUNG-CLD) actually tended to be mistaken for words. The error rate for in context unpronounceable nonwords was 21%, up from 11% for the control. The error rates for pronounceable nonwords were 7.5% out of context and 9% in context. The tentative conclusion was that semantic expectations provide enough information that a word concept can be accessed even given inpoverished spelling or sound information.

A second study was run to generalize this to two syllable words finding of inhibition in rejection of semantically "expected" nonwords. This study tested five types of in-context stimulus pairs: word-word (FOLLY-WISDOM); word-1st syllable-pronounceable nonword (FOLLY-WASDOM); word-list syllable unpronounceable nonword (FOLLY-WJSDOM); word-2nd syllable pronounceable nonword (FOLLY-WISDAM); and word-2nd syllable unpronounceable nonword (FOLLY-WISDGM).

Examining out of context controls only, there was an effect of position of misspellings: misspellings of the second syllable resulted in longer rejection times for nonwords. This supported the notion of left to right processing suggested by the models of Mars en-Wilson and Welsh (1978). Surprisingly, however, the finding of the first study on single syllable

words that close misspellings were harder to reject in context did not extend to the two-syllable words of this study. In fact, a slight facilitation was found for all but the second syllable-unpronounceable condition. This difference between the one and two syllable lists was difficult to explain; however, further investigation suggested that there was a profound difference between the close misspellings of one syllable and two syllable words: Intuitively, it seemed much easier to identify the base word of a two syllable misspelling (like WISDAM-WISDOM) than to identify the base word of a one syllable misspelling (ILD-OLD). A third experiment was run to test these intuitions. Subjects were given a list of nonwords from the two reaction time studies and asked to write down the word that most closely resembled each nonword. The two syllable base words were, in fact, identified much more frequently than the one syllable base words.

With this additional finding, of the studies suggest the following model of word recognition. The model claims that a nonword can be rejected by one of several routes: it can quickly be rejected when the nonword letter string does not result in activation of a potential word concept. If the nonword does activate a potential word concept in memory, then it must be rejected on the basis of an additional spelling check (requiring additional time). One syllable nonwords, out of context, rarely bring to mind their base words and can be rejected quickly, but one syllable nonwords in context will usually serve to activate a potential word concept, and must be rejected after an additional spelling check. This explains the inhibitory effect of context in the first experiment. On the other hand, two syllable words will virtually always activate their base word concept--whether they are in context or not. Therefore essentially all two-syllable nonwords will have to be rejected after the additional stage of a spelling check. The slight facilitatory effect in the second experiment is explained because, while essentially all two syllable nonwords will be rejected after concept activation and spelling check, the relevant concept will be activated more quickly when it is in context.

Word Class Priming: Noun-Verb Repetition. Another study asked whether semantics activation (as measured by reaction time savings in a lexical decision task) resulted only from fairly specific aspects of word meaning. Most studies of semantic priming in the literature, as well as those in the previous set of experiments, have examined pairs of word associates (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt & Ruddy, 1975; Fischler, 1977)-although priming has also been found for related words (AUNT-NURSE) that are not highly associated. However, Schank(1973) has suggested that all verbs are "unpacked" into a very few verb primitives (e.g., verbs of transfer, locomotion, etc.).If this is true then many verbs should have a reasonable level of semantic overlap. Thus, verbs may tend to activate one another, if semantic priming or activation is not specific to full word meaning.

The current study used a long list of nouns and verbs as stimuli. A list of nonwords was created by changing a single letter of either a noun or a verb. The lists were randomly ordered and displayed one at a time for lexical decision. (Note that this display method is different from the usual priming situations, where two words are presented together, or a prime word is presented for reading prior to test word onset.) The reaction time was obtained for nouns and verbs, conditional on the word class of the previous stimulus. The results showed a significant 20 msec savings in lexical decision times when a noun or verb followed a word of the same class. Reaction times were 628 msec for a noun following a verb and 614 msec for a noun following a noun. The average error rates were in the same direction as the lexical decision times.

While there was a significant word-class repetition or priming effect, there was no indication that the verb-priming effect was larger than for nouns. According to Schank, verbs should have shown greater semantic overlap. This result has implications for the standard study of semantic priming. In these studies, the semantic associates are typically of the same word class. Out of context conditions typically share neither an association nor word class. The relative priming attributable to specific associations and to word-class relations should be investigated.

Phonetic and Orthographic Priming. Several studies(partially supported by this project) investigated the effects of non-semantic priming relationships were investigated. Various investigators have offered evidence favoring a primarily othographic (spelling) access to the mental lexicon (Baron, 1973; Bower, 1970; Kolers,1970). Others have presented evidence favoring primarily phonetic (sound) access (Bloomfield, 1942; Gough, 1972; Rubenstein, Lewis & Rubenstein, 1971). We intended to investigate the process of word identification by examining the time course of availability for priming of phonetic and orthographic information by manipulating the stimulus onset asynchrony of the prime and the target.

Previous investigators (Meyer, Schvaneveldt and Ruddy, 1975) have demonstrated that the phonetic and orthographic information in a prime word can affect lexical decision time to a target. They found faster reaction time to pairs, like BORE-MORE, that share both orthography and phonology (O^+P^+); reaction time was slowed for pairs, like DONE-BONE, that share orthography but mismatch in phonology (O^+P^-). The authors argue for facilitatory priming due to either phonetic or orthographic relationships (O^+P^+), with interference when the spelling to sound correspondences mismatch (O^+P^-). However, their studies actually offer no support for the notion that orthographic relationships prime lexical decision. We included the necessary third condition, KITE-HEIGHT, where orthography differs but phonology matches (O^-P^+). We also varied the time allowed to read the prime before target onset between 35 msec and 700 msec, in an attempt to determine whether one kind of information became available earlier than another (Seidenberg & Dosher, 1979; forthcoming).

The results for O^+P^+ and O^+P^- trials replicated those of earlier studies: O^+P^+ pairs showed facilitation relative to randomly repaired control trials; and O^+P^- pairs showed inhibition relative to randomly repaired controls. Interestingly, the O^-P^+ pairs actually showed a greater amount of facilitation than the O^+P^+ condition. This suggests that the priming for both O^-P^+ and O^+P^+ trials is the result of phonetic similarity, with little or no effect of orthography. A simple phonetic similarity explanation does not account for the inhibition in O^+P^- trials. These trials (DONE-BONE) share more phonetic features (the final consonant clusters) than their randomly repaired controls. The combined presence of an orthographic match and a phonetic mismatch are necessary to produce interference.

The locus of these phonetic and orthographic relatedness effects has generally been placed early in the word recognition process: in orthographic to phonetic transcription, or in inproved access to the lexicon. However, there was clear evidence in our study that the locus of these priming effects is later in the recognition process. First, an examination of the error data indicated a small, but significant (9 of 10 processing times) speed-accuracy tradeoffs in all three conditions: conditions with facilitation in reaction time had higher error rates and vice versa. (The previous literature also had this relation in a number of comparisons). While this speed-accuracy tradeoff

may not account entirely for the priming effect, it is clear that criterion shifts are very important. The criterion shifts may be having an effect only late in the word recognition process. This conclusion was supported by the finding that the priming effects were relatively insensitive to the processing time mechanism.

A further study also highlights the importance of strategic processing in producing the orthographic and phonetic priming. This study (Dosher, Helgeson & Manderlink, forthcoming) included nonword prime-word target pairs of the same three types: LORE MORE (O^-P^+);JONE-DONE (O^-P^-), and DITE-HEIGHT (O^-P^+); as well as the three standard word-word pairs: (O^+P^+), (O^+P^-), and (O^-P^+). If priming were mediating early orthographic or phonetic assignment--prior to lexical access--then nonword primes should function just like word primes. However, at fast onset asynchronies between prime and target, word primes have their usual effect while nonword primes have no effect. At longer onset asynchronies, all priming is supressed; again indicating a substantial strategic component to this type of priming.

Clause Boundaries-Comprehension and Retrieval

Two studies examined clause structure in sentence processing. One examined the relationship between clause structure and active memory in comprehension (Chang, in press, Exp. 1). The other examined clause boundary effects in sentence retrieval (Dosher, 1977).

Comprehension. Fred Chang, a graduate student who began working on the project during the second year, investigated the hypothesis that the clause is a basic unit in sentence comprehension (Aaronson & Scarborough, 1976; Caplan, 1972; Fodor, Bever & Garrett, 1974; Jarvell, 1971). This hypothesis proposes that concepts in a clause remain activated in memory during comprehension until they are integrated into a propositional structure. Chang employed a probe recognition task to assess activation. On each trial subjects read a sentence, then were presented with a probeword and asked to decide if the word appeared in the sentence. Response times are faster in this task if the concept referenced by the probe word has been primed or activated. Consider the sentences Now that artists are working fewer hours, oil prints are rare, and Now that artists are working in oil, prints are rare. The word oil appears in the final clause of the former sentence, but not in the latter sentence. Hence the concept should be more activated immediately following the former sentence and response times to the probe oil should be faster. Caplan (1972) confirmed the hypothesis when auditory input is employed and Chang extended the result to visual input.

Retrieval. A further project partially supported by this grant, investigated properties of information retrieval from single clause and multi-clause sentences (Dosher, 19770). Single clause sentences were of the form: The architect sold the trunk (S-V-O). Multi-clause sentences embedded an S-V-O-L clause as the object of a higher level clause containing a complement verb, i.e., The official believed that the architect sold the trunk at the store (S'-V'-that(S-V-O)-L). These two sentence forms were chosen to test the effects on memory retrieval of (1) embedding an S-V-O kernal in a larger sentence structure, and (2) testing information that crosses the clause boundary.

Subjects learned lists of single-and multi-clause sentences and then participated in a pair recognition task. Two words were presented on each trial and

subjects decided if they had appeared in the same sentence in learning. A variety of comparisons were undertaken. Recognition performance was compared for pairs drawn from single clause sentence (SV,VO, and SO) vs. pairs drawn from embedded clauses inthe multi-clause sentences (again, SV,VO or SO). The single-clause sentences were identical in form (and similar in content) to the embedded S-V-O clauses of the multi-clause sentences. Therefore, this comparison reveals the effects of embedding information in a larger structure in memory. Such embedding also occurs when propositions are integrated into larger story structures in memory.

The other major comparisons examined recognition of pairs involving cross-clausal information (e.g., CLAIMED-TRUNK) to same-clause pairs (e.g., SOLD-TRUNK). Comparing within-clause to cross-clause retrieval should reveal effects of distance between items in representational networks, since cross-clause pairs would be more distantly related in the memory structure. Distance here is within a single sentence; greater distance effects would presumably be found in story or episode representations.

The predictions of several models of retrieval from network memory were discussed. Among these models were a holistic storage model (similar to the trace resonance model of Moesser, 1977); a guided serial link search model (Anderson & Bower, 1973); an unguided serial link search algorithm; several spreading activation models (Collins & Loftus, 1975; King & Anderson, 1976); a continuous spreading activation simulation (Dosher, 1977) and Wickelgrens (1976a) network strength theory.

The major experiment of the project used an interruption procedure (Reed, 1973) to produce a seven-point retrieval function (a plot of response accuracy as a function of elapsed processing time). The procedure allows a separation of the overall accuracy level, obtained with ample processing time, from retrieval speed.

Analyses revealed significant differences in asymptotic accuracy levels among various conditions. Most notably, response accuracy was greater for within-clausal pairs than for their cross-clausal counterparts. (There was also a difference in overall response accuracy for single-clause pairs and comparable constituents of the multi-clause sentences. These effects are not of theoretical interest, due to differences in study time and amount of material to be learned). Retrieval speed was analyzed by fitting an exponential approach to a limit to the retrieval functions. One parameter of this equation represents asymptotic accuracy and two parameters reflect the amount of time required to approach this maximum accuracy. The analyses revealed no substantial effects on retrieval speed of crossing a clause boundary or of embedding a clause in a larger sentence frame. If there was a trend, it was in the direction of a very slight slowing for cross-clause retrieval relative to within-clause retrieval; and for embedded clauses relative to non-embedded clauses. Neither of these trends approached significence. Thus, the effects of network distance and embedding primarily affected overall accuracy levels rather than retrieval speed. Therefore enlarging a data base in memory (e.g., building propositions into integrated text structure in memory) need not result in slower retrieval.

These results conflict with predictions of four of the models tested. The holistic storage model and the unguided serial search model predict a substantial slowing in retrieval due to embedding, while a guided serial link search model and spreading activation models predict a substantially slowed retrieval for more distantly related items. No substantial slowing due to either manipulation was observed.

either manipulation was observed.

Both Wickelgren's network strength theory and Dosher's continuous spreading activation theory suggest that activation in some form spreads through a network before any nodes in the network reach maximum activation (i.e., are retrieved). Both models accomodate the finding of little or no slowing in retrieval due to embedding or distance. Wickelgren's model can also accomodate asymptotic accuracy differences while Dosher's model actually predicts the lower asymptotic accuracy obtained in cross-clausal retrieval.

This project also included a reaction-time phase, which examined the relationship between mean reaction time and the seven-point retrieval functions. While mean reaction time was somewhat related to retrieval speed parameter estimates (r_s =.35), reaction time was much more strongly related to overall (asymptotic) accuracy level (r_s =-.77). These results suggest that caution must be exercised in interpreting mean reaction time as a measure of memory retrieval speed.

Syntax

Context Sensitive Coding. Wickelgren(1979) generated a framework for the representation of (procedural) syntactic knowledge as it interacts with (declarative) semantic knowledge in reading, writing, speech production and speech recognition. The basic idea is an extension of the context-sensitive coding system developed by Wickelgren for the representation of linear orderings of letters or phonemes in a written or spoken word (Wickelgren, 1969a, 1969b, 1972, 1976b). Context sensitive coding permits the representation of an ordered set of items or states (a procedure) by means of an unordered set of nodes.

As Lashley (1951) pointed out, an unordered set of context-free nodes representing single states in inadequate to represent the order of the elements. Thus, the unordered set of letters in the word "stale" is not adequate to uniquely represent the word, since the same set underlies "stale" and "steal", not to mention a variety of non-words adhering to the orthographic roles of English, e.g., "setal". However, context sensitive coding allows this sequence to be encoded as an unordered set of nodes consisting of overlapping triples of states:

$$\#^{s}t,s^{t}a,t^{a}l,a^{l}e,l^{e}\#.$$

Context-sensitive coding allows for perception of the overlapping triples in parallel and retains order information without requiring separate nodes to represent a letter in every possible serial position.

At a higher level of processing, context-sensitive coding can be used to represent syntactic knowledge. The lowest level syntactic classification of a noun phrase such as "The energetic old man who lives near the school" could be represented by a context-sensitive code such as:

$$\#^{the}Adj,\ The^{Adj}Adj,Adj^{Adj}N,\ Adj^{N}who,\ N^{who}V,\ who^{V}Prep,\ V^{prep}the,$$

$$prep^{the}N,\ The^{N}\#.$$

The N,V and Adj. classes might be more finely subdivided (e.g., to distinguish animate and inanimate nouns) and grammatical function words (e.g., the, who) might be generalized to classes (e.g., Det, wh), but such specific decisions

are not a present concern. The present concern is that context-sensitive coding of syntax by means of overlapping triples of syntactic categories, provides a functional encoding of procedural knowledge. This encoding permits parallel activation of syntactic elements while retaining necessary order information in both language recognition and production.

Context sensitive coding of syntactic knowledge can be hierarchical. That is, phrase order may be represented at one level, by nodes such as

$\#^{\text{Agent}}\text{Verb}$, $\text{Agent}^{\text{Verb}}\text{Object}$, $\text{Verb}^{\text{Object}}\#$; (active sentnece)

or $\#^{\text{Object}}\text{Verb}$, $\text{Object}^{\text{Verb}}\text{Agent}$, $\text{Verb}^{\text{Agent}}\#$; (passive sentence).

Each context-sensitive phrase node may be associated in turn with context-sensitive constituent nodes, which are in turn associated to the specific concepts in the sentence. Finally, procedural knowledge or plans that contain looping or branching of control can be represented by sets of context sensitive nodes (state nodes and action nodes). Context-sensitive coding is an alternative to production systems or augmented transition networks for the representation of procedural knowledge.

Syntactic Category and Retrieval. Two studies examined the impact of syntactic role information on recognition. Most theories of propositional representation in memory make extensive use of role-labelled links that associate concepts. That is, links between concepts and proposition nodes are labelled as representing relations: verbs, objects, agents, etc. While these labels may be necessary in some logical sense for the representation of meanings, there is no good empirical evidence for the functional importance of syntactic role information in recognizing propositions.

The first experiment presented subjects with a series of reversible agent, verb, object (AVO) sentences, for example, The doctor liked the engineer. The sentences were studies for 10 sec. each, followed by a 20 minute distractor task, and finally by a recognition test. Test stimuli were true (old) or they were false(new). Some new sentences were recombinations of two sentences that maintained the syntactic role of all constituends (A'VO, AV'O, AVO'). Other new sentences violated the syntactic role of some constituent. (O'VA, AVA', OV'A). Last, OVA new sentences reversed roles of items in a learned sentence. The data of interest were the false alarm rates (propostion of "old" responses) to these new sentences. The results show the highest false alarm rates to OVA test sentences (13%), where all the words came from the same learned sentence but are rearranged. The false alarm rate for new sentences maintaining syntactic role was 10% and the false alarm rate for new sentences with inconsistent syntactic roles was 8%. Thus, there was some slight evidence for memory for syntactic information independent of semantic content (10% vs. 8%, $p < .11$).

The effects in the recognition experiment were small because recognition accuracy was high. Also, the experiment did not distinguish between the effect of surface role and deep role, since only active constructions were used. Therefore, a second experiment included both active and passive constructions and used reaction time for recognition as a pontentially more sensitive measure. Otherwise, the experimental conditions were the same. The results of this experiment, while somewhat more complicated, supported very similar conclusions. There appears to be some impact of role information per se on ease of recognizing false sentences. But the impact of this information on recognition appears

to be small. This suggests that, while role information may be logically necessary for representing meaning in networks, it does not have a large impact on recognition independent of semantic content.

Integration-Anaphoric Reference

Pronoun Disambiguation. Several sets of studies have examined the integration of propositions into a text struction. One set of studies (Chang, in press, Exp. 2; Corbett & Chang, forthcoming) has begun examining the disambiguation of anaphoric reference, specifically pronoun reference. These studies examine the hypothesis that the first step in an anaphoric reference is to access potential antecedents in memory. These studies employed a probe rccognition ask to measure concept priming or activation (as in Chang, in press, Exp.1, described earlier). On each trial, subjects read a sentence. Following the sentence a probe word is presented and subjects decide as quickly as possible if the probe word is in the sentence. Positive response times are faster if the corresponding concept has been primed in memory.

In processing an anaphoric reference, the set of potential antecedents corresponds, it appears, to concepts currently or recently activated (Clark & Sengul, 1979; Lesgold, Roth & Curtis, 1979; Springston, 1979). In addition, Chang (1979) demonstrated that the set of potential antecedents is restricted to examples of the anaphoric category (e.g., females, in the case of the feminine pronoun, she). In Chang's study, subjects read two clause sentences of the following form: Bill and Mary went to the store and he bought a quart of milk. Two humans, one of each sex, served as a compound subject of the first clause, and one of them served as the subject of the second clause (the other was not repealed). There were four versions of each sentence, each with a different second clause subject (e.g., Bill, he, Mary, or she). After each sentence a probe word was presented. The critical probes were the names in the sentence (Mary, Bill).

As expected response times to the probe Mary were faster if the second clause subject were Mary than if it had been Bill. This is to be expected since Mary has been more recently activated than Bill. Response times to the probe Mary were slower following she than following Mary (reflecting a name match effect); but responses to Mary were still significantly faster following she than following Bill. This indicates that the task is sensitive to conceptual codes as well as name codes. Finally, response times to Mary were no faster following a second clause subject he than following Bill. Since the task is sensitive to conceptual codes, this result indicates that the concept Mary is not accessed when processing the anaphoric reference he. Thus, it appears that feminine and masculine pronouns only activate potential antecedents of the appropriate sex.

Three additional studies employed a probe recognition task to examine the primary hypothesis that the first step in disambiguating an anaphoric reference is to access potential referents. In the first study, subjects read two-clause sentences of the form Larry wrote a letter to Bill, but he forgot to mail it. Two humans of the same sex were referenced, one as subject, one as object. The second clause subject was co-referential with the first clause subject (the first clause object was not repeated). The second clause subject was either a pronoun (as in the example) a proper name (e.g., Larry wrote a letter to Bill, but Larry forgot to mail it), or an elliptical construction (e.g., Larry wrote a letter to Bill, but forgot to mail it). A probe word followed each sentence, and again, the critical probes are the names in the sentence (Larry, Bill).

As expected, response times were faster when the probe (e.g., Larry) named the second clause agent than when it named the first clause object. The name match effect was non-significant. That is, response times for the probe Larry were not significantly faster following a second clause subject Larry, than following a second clause subject pronoun reference to Larry or an elliptical reference to Larry. Response times were slowest overall when the probe named the first clause object (e.g., Bill) following a second-clause proper name (Larry). Most importantly, response times to this probe (Bill) were significantly faster following a second clause pronoun or elliptical reference than following a second clause proper name. This result indicates that in disambiguating a pronominal reference to Larry, the non-antecedent Bill is accessed, as the hypothesis predicts. The results also indicate that the non-antecedent is accessed in processing the elliptical reference. This is interesting, since the construction is syntactically unambiguous (an elliptical second clause subject must be co-referential with the first clause subject). Apparently subjects are unable to employ syntactic information efficiently to uniquely access the first clause subject.

Two additional studies were conducted, similar to the previous one, except that in the key conditions the second clause subject was co-referential with the first clause object rather than with first clause subject. The second clause subject was referenced by proper name (e.g., Tom threw a pass to Dave, and Dave caught it in the endzone), or by pronoun (e.g., Tom threw a pass to Dave and he caught it in the endzone). Again, the critical probes were the two names in the sentence (Tom, Dave). The results of the first of these two studies were somewhat surprising. Unlike earlier studies, response times were not significantly faster when the probe matched a second clause constituent rather than just a first clause constituent. This result suggests that the first clause subject may be given a special status as the "topic" of the sentence in comprehension. More importantly, probe response times revealed no evidence of priming of the non-antecedent in pronoun processing (response times to the probe Tom were no faster following he than following Dave).

The sentences in this study (and prior studies) were presented on a word-by-word basis. Subjects pressed a key to see each new word. The sentences in the last study in which the second clause pronoun is co-referential with the first clause object are somewhat more difficult to process than sentences in earlier studies (cf., the parallel function strategy, Carramazza, Grober, Garvey & Yates, 1977). If subjects fall into a rhythm of key pressing in comprehension, then in the pronoun conditions in particular, subjects may press the key following the last word in the sentence before they have finished processing the sentence. Such an effect would artifactually lengthen probe response times in the pronoun conditions, attenuating or eliminating any non-antecedent priming effect.

To examine this possibility, the study was replicated, but with clause-by-clause presentation of the sentences, rather than word-by-word presentation. The second clause subject was, again, co-referential with the first clause object. With the change in sentence presentation method, probe response times did reveal priming of the non-antecedent. That is, response times to the non-antecedent (Tom in the example) were faster following a second clause pronoun reference (to Dave) than following a proper name (Dave).

Text Structure and Retrieval of Prior Information

In comprehension, the reader is required to integrate incoming information (propositions) into the existing text structure. Propositions become integra-

ted when they refer to concepts (persons, objects, actions) already in the text (Kintsch, 1974; Kintsch & Van Dijk, 1978). New propositions are also integrated when higher order relations are inferred that link the new propositions to propositions already in the text base. Consider the sentence The gambler ran away when he saw the angry sailor coming. To integrate this with prior text, the antecedents in the text (the gambler and policeman) must be accessed. In addition, the sentence The gambler owed the sailor money had appeared earlier, then the reader might infer higher order relations (e.g., The sailor is angry at the gambler because the gambler hasn't paid up) that integrate the new propositions into the text. To accomplish this, the reader must retrieve abstract knowledge of the world (e.g., why people get angry and how they are likely to act as a result) and prior information in the text (e.g., the gambler, the sailor and the proposition that the gambler owes money to the sailor).

We have a series of studies that examine the retrieval of prior information in a text and aspects of text structure that affect the availability of such information. Two studies (Corbett & Dosher, forthcoming) examine the availability of information in a text as a function of its significance in the story. Concepts and propositions in a text range from being central in importance to being incidental. The notion of importance of information has been formalized recently in a number of theories of text structure (Kintsch, 1974; Meyer, 1975; Schank, 1975). or text grammar (Mandler & Johnson, 1977; Thorndyke, 1977). The present studies compare the effects of importance and frequency on availability.

These studies focused on individual concepts (rather than propositions) and examined reading time for an anaphoric reference as a function of prior experience with the antecedent. Subjects read a series of stories each consisting of two paragraphs The stories were presented a few words at a time and subjects controlled presentation rate by pressing a key for each new set of words. In the first study, the second paragraph contained an anaphoric reference to an antecedent that appeared in one of four conditions. In two conditions the antecedent (e.g., an umbrella) appeared in the first paragraph. In one case it was of central importance (e.g., a man had just received an umbrella and took a walk in the rain to try it out) and was referenced several times. In the second case, the antecedent was incidental and referenced once (e.g., a man took a walk and grabbed the umbrella on the way out). The third condition was identical in form to the second, but the incidental reference appeared at the beginning of the second paragraph. In the fourth condition there was no explicit reference to the antecedent and the reader had to infer its existence in comprehending the "anaphoric" reference.

Analysis of the reading times revealed a significant effect of prior experience with the antecedent. Further comparisons revealed that a reference to a high frequency, centrally important antecedent was encoded faster than a reference to a new concept and faster than the average of the two incidental conditions. The difference between the two incidental conditions was small and non-significant. Mean reading time for the incidental conditions was (non-significantly) shorter than for a new concept. Thus, evidence was obtained that prior experience with individual concepts affects retrieval times, even when the time interval between the anaphoric reference and antecedent is relatively short (on the order of one minute or less). Interestingly, there was little or no difference in reading time for retrieving incidental concepts and encoding new concepts.

A second study was conducted to distinguish between centrality and frequency effects. In this study subjects again had two-paragraph stories, a few words at a time, at a self-paced rate. Again, the dependent measure was reading time for an anaphoric noun in the second paragraph. There were four conditions defined in relation to prior references to the antecedent of the anaphoric noun. Two levels of importance of the antecedent (central or incidental) were crossed with two levels of frequency (one or four prior references). For example, one story concerned a journey and the anaphoric reference in the second paragraph was to an old plane wreck. In the centrally important condition, the plane wreck had been described as the goal of the journey. In the peripherally important condition, the wreckage was just passed in the course of the journey. Within each of these conditions the antecedent (the plane wreck) was mentioned either one or four times in the first paragraph.

Analyses indicated that frequency affected encoding time for the anaphoric reference. Such references are encoded more quickly if the antecedent appeared four times previously rather than one. There was no significant effect of importance, however, nor an interaction of frequency and importance. At least for very short stories (and short storage intervals) retrieval time seems to be a function of the frequency of the antecedent (i.e., the strength or number of repetitions of the antecedent in the text base), rather than the importance of the antecedent (i.e., position in the text base).

An additional study was completed that examines a different aspect of the availability of prior information in text. Stories, except for the very simplest, consist of multiple episodes. This study investigated the possibility that a reference to a prior episode may activate constituents of the episode making them more available for retrieval.

In this study subjects read a story describing a trip consisting of eight episodes that could be identified by simple labels (e.g., taxi ride or circus). There were four major characters common to all the episodes, but the episodes were otherwise largely independent of each other. In addition, two different target characters appaared in each episode. One character was highly associated with the abstract episode schema (e.g., a taxi driver or clown) while the other was not (e.g., a politician or sailor). In a concluding paragraph, the two target characters from each episode were referenced either with or without an immediately preceding reference to the episode in which they appeared. Subjects read the story one word at a time, at a self-paced rate, and the dependent measure was reading time for the anaphoric references to the target characters in the final paragraph.

Analyses revealed that an immediately preceding reference to an episode does not speed encoding of the characters in the episode. Earlier studies suggest that reading time is sensitive to the availability of concepts. Therefore, the tentative conclusion is that a reference to an episode need not automatically activate the episode structure in a manner that makes its constituents more available for retrieval.

Theory of Context Representation in Text.

A new theory of context representation in narrative text structures has been generated. In connection with this theory, recall studies have been conducted that examine the retrieval of information from text structures and the retrieval cue effectiveness of context-free and context bound adjectives. This theory concerns multi-episode stories. It assumes a network representation of

text. Specifically, it assumes that a story is represented by a tree structure dominated by a single node that represents the story as a whole. It assumes that each episode in the story is dominated by a node that represents the episode and, of course, that concepts and propositions are represented by nodes.

The theory recognizes two levels of context: the story context and the episode contexts. The story provides a context for all propositions in it (this is particularly true of fiction). That is, the truth value of a proposition is only defined within the context of the story. For example, the statements Cinderella went to the ball and Cinderella found the prince's shoe are true and false, respectively, but only within the domain of that particular fairy tale. Moreover, within the story, the truth of most propositions is further restricted. Most information within any episode is only true within the context of the episode. Sentences such as The man kicked the ball and The man is hungry are only true in the episode in which they appear. Some information in an episode is not restricted to the episode, e.g., The man is tall. Such information is generally true and may be abstracted out of the episode context and conditioned only by the story context.

The theory makes two major points. First, a distinction is drawn between context and setting (location and time), although the two are typically assumed to be synonymous. It is proposed that the context of a proposition is strictly the episode in which it occurs and not the setting in which it occurs. Location and time are attributes of an episode context and may, in fact, remain undefined.

The second major contribution of the theory is the suggestion that context may be encoded through a token node representation of concepts in the story. Previous models have suggested that a proposition is contextualized through higher order relations that accept the proposition (node) as an argument and link the proposition to a context node. In these theories propositions that are generally true and not just true in the episode (e.g., The man is tall) are abstracted from the current episode by failing to embed the propositions in a higher order contextualizing relation. (Such generally true propositions will be referred to as context-free: They are not bound to episode context, although they are still bound to the story node). The present theory, instead proposes that each character or object in a story is represented by a general type node and a set of token nodes. The type node representing a character or object is directly associated with the story node. A new token node is generated to represent a character or object in each episode in which the character or object appears. These token nodes are associated with the concept's type node and with the appropriate episode node. All context-free propositions are associated with the character's or object's type node while context-bound propositions are associated with the appropriate token node. This type-token system is particularly advantageous for drawing inferences because it structurally separates context-free or "permanent" propositions from context-bound or "temporary" information. When a character or object is referenced during comprehension, context-free information (which is true across episodes) may be activated by activating the concept's type node. A model in which context is encoded through higher order relations does not permit such efficient activation of context-free propositions.

Results have been obtained (Corbett, 1977) concerning the encoding of context-free and context-bound adjectives that are consistent with the theory. In a series of experiments subjects read a story that described the activities of a family. The story consisted of four episodes (operationally defined by paragraph structure and discontinuities in action and setting). Several

adjectives, each describing a member of the family were embedded in the paragraphs. Half the adjectives werecontext-bound or "temporary", that is, only true in the current episode. The other half were context-free or "permanent, that is, true in general not just in the current episode. After reading the story the subjects were presented with a list of the adjectives and were asked to write down the person modified by each adjective and the episode in which each of the adjectives occurred. The theory predicts an interaction of adjective type (temporary or permanent) and retrieval target (person or episode). Permanent adjectives should be abstracted from context and therefore should serve as worse episode cues than temporary adjectives. Temporary adjectives are associated to the character concept by a longer associative chain of links in the network than are permanent adjectives, and therefore, permanent adjectives should serve as better person cues than temporary adjectives. In fact, these predictions were confirmed by the results.

Chunking and Consolidation

Wickelgren (1979), in a project partially supported by this grant, has developed a theory of chunking and consolidation. The theory begins with the basic notion of a chunk (Miller, 1956) and proceeds to define a precise distinction between vertical associations and horizontal associations. The difference between the two types of learning concerns whether new nodes are added to memory as a result of the learning process. The theory distinguishes between bound nodes and free nodes. A bound node has strong associations to other bound nodes and these associations define what the node means. Nodes in semantic networks or text structures are, in effect, bound nodes that represent concepts and relations. Free nodes have a multiplicity of weak associations, and as a result represent no fixed concept. In acquiring horizontal associations, associations are strengthened between existing bound nodes as a result of contiguous activation. Ultimately the activation of one node may be sufficient to activate all others in one associative cluster. In acquiring vertical associations, on the other hand, a set of bound nodes become associated with a previously unspecified free node, which is bound as a result. This new chunk node may represent a concept and the original set of bound nodes its constituents; or the new node may represent a proposition and the original bound nodes its component relation and arguments.

Wickelgren proposes, on the basis of phylogenetic differences in learning, and human and animal amnesic syndromes associated with hippocampal lesions that the hippocampus controls acquisition and consolidation in vertical associations (which are formed in the cortex). The hippocampal system is assumed to have excitatory synapses with free nodes (cortical neurons or groups of neurons). In chunking (formation of vertical associations) free neurons are activated so that some set or chain of free neurons is maximally activated by a set of bound neurons (e.g., in proposition encoding), rather than some set of other bound neurons. When a free node forms strong associations to a set of bound neurons the excitatory synapses with the hippocampal system are progressively repressed over time (consolidation) and the chunk becomes progressively resistant to interference. Hence, disruption of the hippocampal system leads first and foremost to anterograde amnesia (an inability to form new chunks). When retrograde amnesia does occur (and it does not occur in the absence of anterograde amnesia) it is the most recent vertical associations that are disrupted. These associations primarily involve free neurons still partically associated with the hippocampus. And finally, anterograde amnesics, in fact, appear capable of strengthening existing associations between bound nodes (e.g., can learn lists of semantic associates such as bowl-plate) but appear unable to form new vertical associations.

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Dissemination Activities

Papers

Chang, F.R. Active memory processes in visual sentence comprehension: and pronominal reference. (M.A. Thesis, University of Oregon, 1978), Memory and Cognition, in press.

Corbett, A.T. Context representation in the coding of narrative text. Ph.D. dissertation, University of Oregon, 1977, submitted for publication.

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Corbett, A.T. & Chang, F.R. Activation of concepts in the disambiguation of anaphoric reference. Forthcoming.

Corbett, A.T. & Dosher, B.A. Instrument completion norms for 67 sentences. Unpublished manuscript, 1977.

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Dosher, B.A. The impact of syntactic role on sentence memory. Forthcoming.

Dosher, B.A. & Corbett, A.T. Instrument priming in sentence comprehension. Forthcoming.

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Talks

Corbett, A.T. Talks presented at:

Center for the Study of Reading, University of Illinois, Champaign-Urbana, IL.
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Department of Psychology, Wayne State University, Detroit, MI
Department of Psychology, University of South Carolina, Columbia, SC
Department of Behavioral Sciences, University of Chicago, Chicago, IL
Department of Psychology, Catholic University, Washington, D.C.
Department of Psychology, Lehigh University, Bethlehem, PA

Chang, F.R. Talk presented at:

Western Psychological Association Convention, San Diego, CA

Dosher, B.A. Talks presented at:

Department of Psychology, University of Iowa,
Bell Laboratories, Murray Hill, NJ
Department of Psychology, Columbia University, New York NY
Department of Psychology, State University of New York, Stonybrook, NY
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Wickelgren, W.A. Talks presented at:

Department of Psychology, McMaster University, Hamilton, Ontario, Canada
Department of Psychology, University of Toronto, Toronto, Ontario,Canada
Psychonomic Society Convention, Washington, D.C.
Interdisciplinary Conference, Jackson Hole, Wyo.
Psychonomic Society Convention, San Antonio, Texas
University of California, Berkeley, Calif.
University of California, San Diego, Calif.
University of Sussex, Brighton, England
Applied Research Unit, Cambridge, England
International Conference on Speech, Edinburgh, Scotland
Psychonomic Society Convention, Phoenix, Ariz.
University of Washington, Seattle, WA